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THE EFFECT OF SWITCH-HANDLE SHAPE
UPON THE TIME REQUIRED FOR OPERATION

A Thesis

Submitted to the Faculty

of

Purdue University

by

Richard Henry Doolittle

"

In Partial Fulfillment of the

Requirements for the Degree

of

Master of Science

in

Industrial Engineering

June, 1952

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. M. E. Mundel, Dr. I. W. Burr and Professor H. T. Amrine for their assistance and guidance in the pursuit of this investigation. The indebtedness to the students and others who so generously donated their time as subjects for the experiment is cheerfully acknowledged.

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REPORT ON THE

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2. The study was conducted in a controlled environment, and the results were compared to the control group. The results of the study are presented in the following sections.

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ABSTRACT

This investigation was undertaken to determine whether some one of several common shapes of handle for a generally-used type of switch would provide for a minimum of time required to operate the switch.

The time required by fifteen male operators to rotate a set of four switches to four different angles using five shapes of switch handles was measured.

The overall average times obtained (in hundredths of seconds) are as follows:

	30°	60°	90°	120°
Handle 1	189.6	225.9	259.0	300.3
Handle 2	174.6	222.8	240.3	281.3
Handle 3	199.2	233.3	276.0	317.1
Handle 4	167.4	221.0	251.7	296.8
Handle 5	188.6	236.5	275.5	315.0

An examination of the data shows that the round shapes of handles provided for the higher operating times while the generally rectangular shapes provided for the lower operating times.

THE EFFECT OF SWITCH-HANDLE SHAPE UPON THE TIME REQUIRED FOR OPERATION

INTRODUCTION AND PURPOSE

A review of the literature shows that some consideration has been given to designing switch-handle shapes for appearance and indication of function¹. Inquiries made at some of the leading electrical apparatus manufacturers, such as General Electric Company, Westinghouse Electric Corporation and Arma Corporation, reveal that industry has investigated the design of switch-handle shapes for appearance, feel to the hand and, in some cases, to provide better leverage for operation.

Apparently little consideration has been given to designing the shape with the thought in mind of providing for minimum operating time², as may be desired in the case of control panels for communication or radar equipment, computing machines and the like. Thus, this investigation was undertaken to determine whether some one of several common shapes of handle for a generally-used type of switch would provide for a minimum of time required to operate the switch.

1. Price, Wesley, "Why Pilots Make Mistakes", Saturday Evening Post, April 19, 1947, p. 18.
2. Raines, Arnold, and Rosenbloom, J. H., "Ideal Torques for Handwheels and Knobs", Machine Design, August, 1946, pp. 145-148.

ORIGINAL ARTICLES

A Study of the Literature on the History of the

History of the American Medical Association, 1847-1912

By J. H. HARRIS, M.D., Secretary of the Association

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1. The American Medical Association, 1847-1912
Published by the American Medical Association

2. The American Medical Association, 1847-1912
Published by the American Medical Association

APPARATUS

The equipment used to measure the time required by the several operators consisted of the following: a plywood panel on which were mounted four ten-position rotary switches (Figs. 1 and 2), a relay and a normally-closed microswitch; a table upon which the panel, timing clock and power supply rested; a chair for the operator; a direct-current power supply for the timing clock and the relay; an electric clock which could be read to 1/100th of a second; and the required wiring.

The chair, an unpadded, wooden, straight-backed piece of furniture, was placed so that its centerline coincided with a line midway between the four switches and at a distance from the panel dependent upon the forearm measurement of the operator. The panel was adjusted vertically so that the elbow of the operator, when seated and when the upper arm was vertical and held against the side with the forearm at right angles to it, was ten inches below the center line of the switches. The dimensions and layout of the equipment are given in Figures 1, 2 and 3.

The switches used were commercially-obtained, ten-position wafer switches with spring ball detents. The average maximum torque required to rotate the switches from one detent to the next was three inch-pounds. The switch handles were also commercially-obtained. For the shapes and dimensions of these handles see Figures 4 and 5.

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without management; a 1992 study with the same 15 cases

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disco-topologie, wenn die folgenden 3 Bedingungen erfüllt sind:

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Substantive work begins with the identification of the problem to be addressed.

[illegible]

and the other two are the same as in the previous case.

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Notes for number line at the reference: The dimension is

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we suggest to the study the following:

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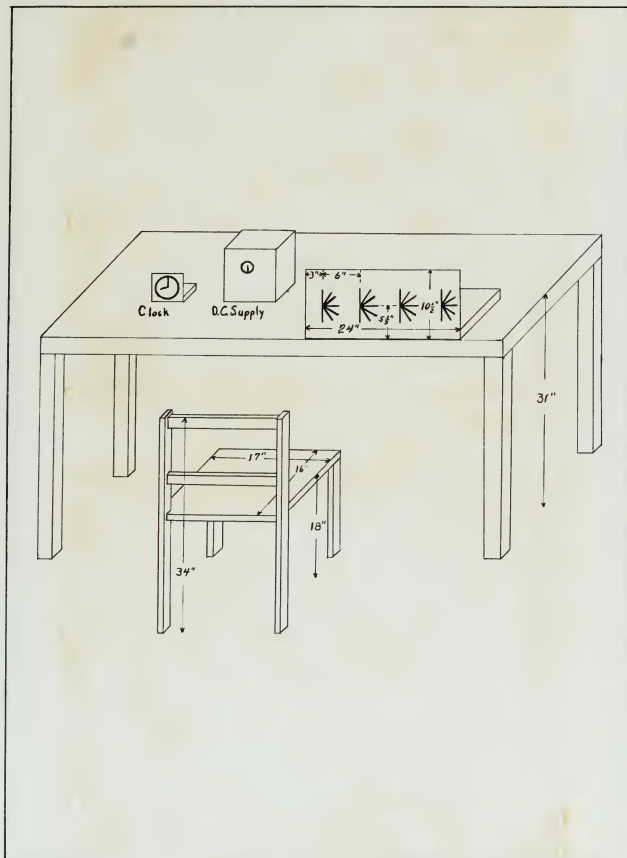


fig. 1

Layout of equipment

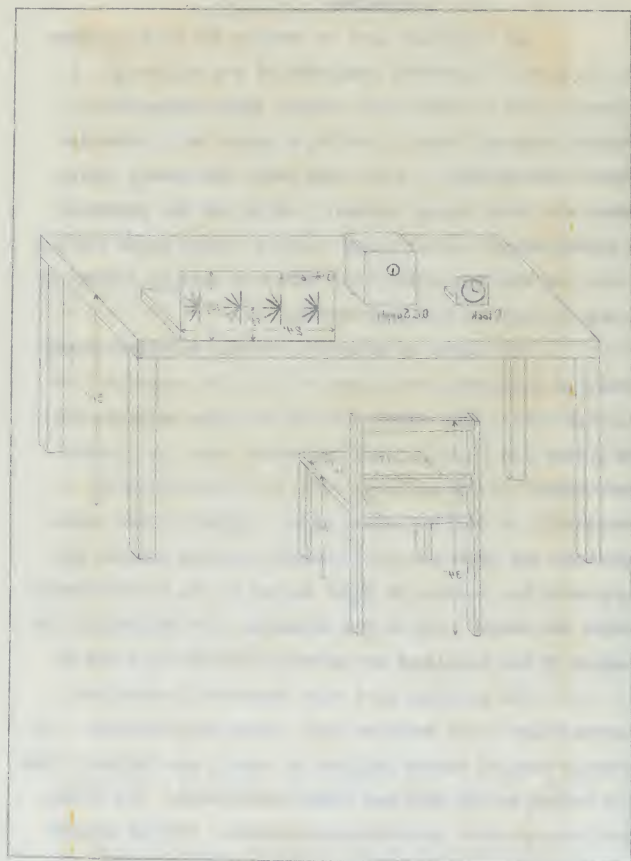


Fig. 1
Diagram of a chair



Fig. 2 View of equipment in operation



Fig. 3 Rear view of equipment

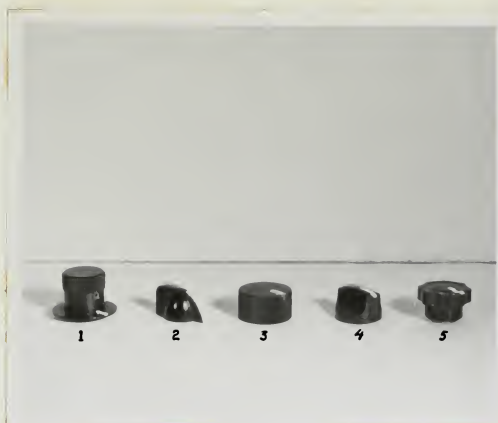


Fig. 4 Switch handles

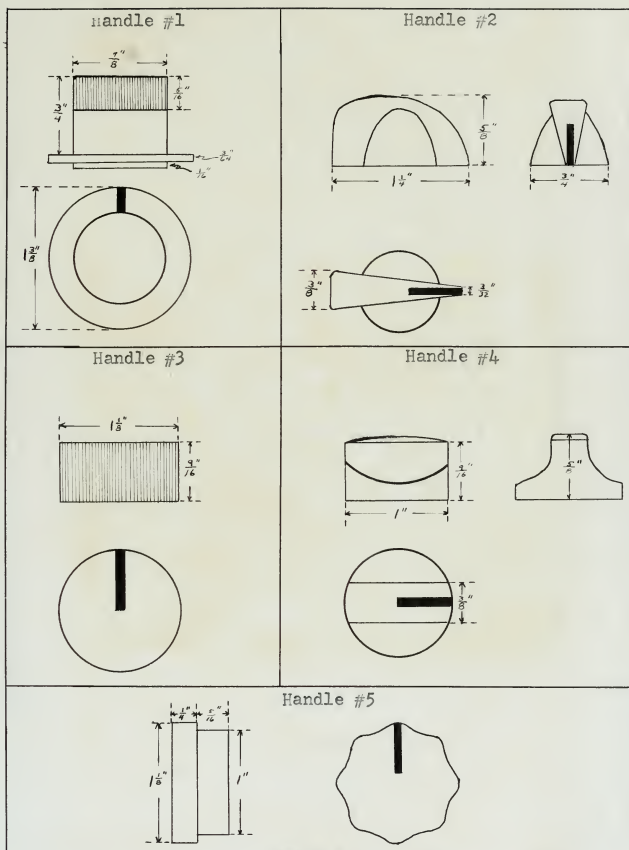
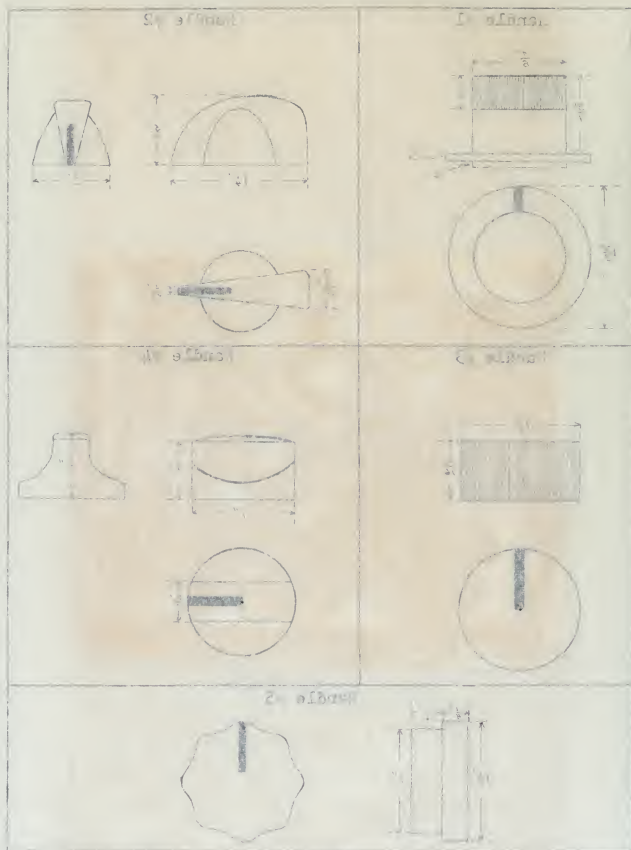


Fig. 5

Dimensions of switch handles.

Fig. 2. Dimensions of twisted samples.

Fig. 2



The plane of rotation of the switches was vertical and the switches were rotated in the clockwise direction only. The test was limited to clockwise rotation in order to eliminate the effect of opposite directions of rotation. The angular positions of the switches were marked on the panel by quarter-inch wide colored stripes: black for the 0 degrees or vertical position; light blue for the 30 degree position; bright red for the 60 degree position; yellow for the 90 degree position; light green for the 120 degree position; gold for the 150 degree position; and black for the 180 degree position. Each switch handle was marked with a one-sixteenth inch wide white stripe (Figs. 4 and 5) which served as an index. The background around the switch handles and stripes was aluminum.

The microswitch was so positioned to a cam on the shaft of the left-hand switch that, as soon as the switch started to move, the circuit to the timing clock was closed and the clock began to run. The right-hand switch was wired to a relay so that the circuit to the clock was broken when the switch reached its designated position. This connection was changed for each required set-up so that the clock would stop when the required position was reached. The wiring diagram is illustrated in Figure 8.

The clock used was of the type in which the motor runs continuously while the movement of the hands is controlled by a solenoid-operated brake on a friction drive. Thus, the effect of inertia in the driving mechanism of the

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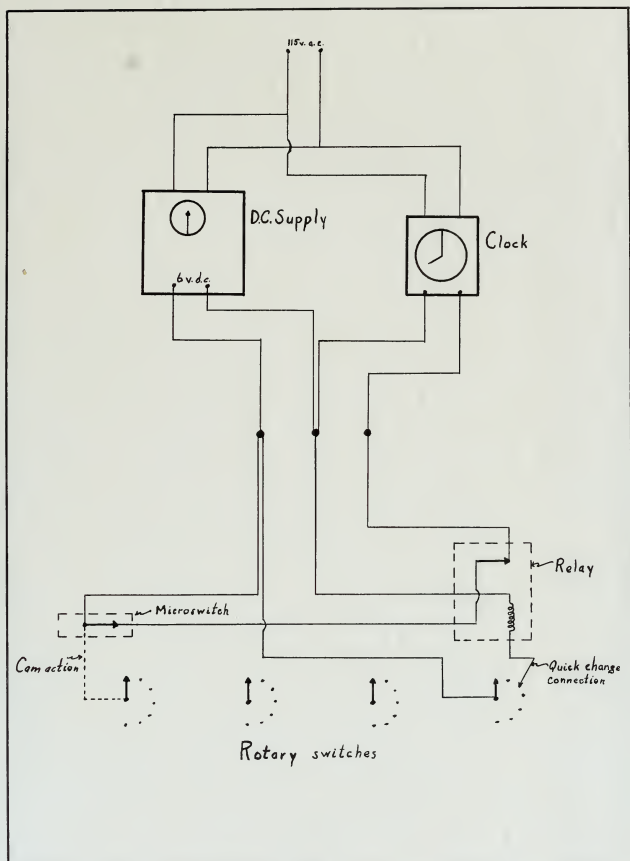


Fig. 6

Block wiring diagram

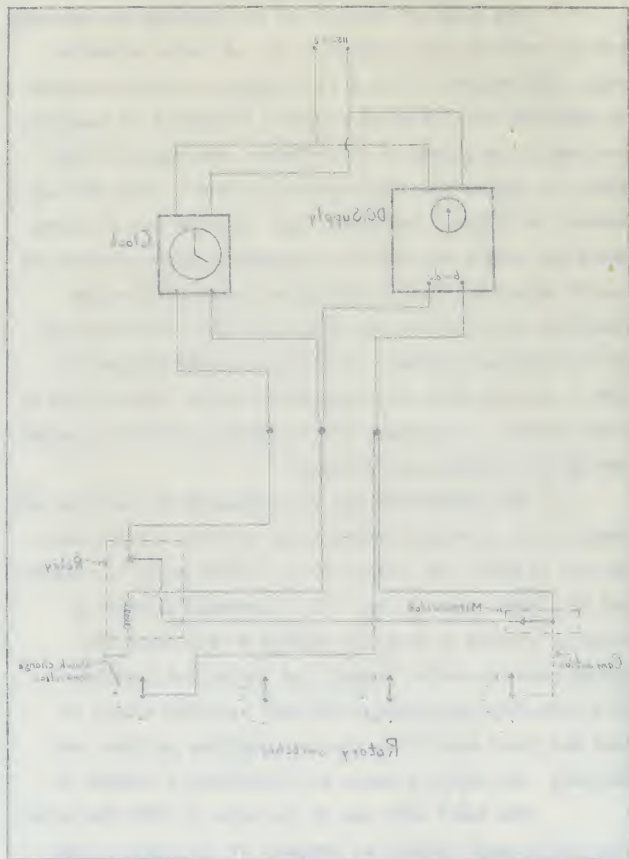


Fig. 1
Timing circuit diagram

hands is minimized.

The power supply was a battery charger which required an input of 115 volts a.c. and which had an output of 6.5 volts d.c. The clock motor required 115 volts a.c. while the solenoid-operated brake and the relay required 6 volts d.c.

The first part of the report is a summary of the work done during the year.

The second part of the report is a detailed account of the work done during the year.

The third part of the report is a summary of the work done during the year.

The fourth part of the report is a summary of the work done during the year.



PROCEDURE

In order to facilitate the application of the experimental results to actual equipment, an attempt was made to present the test problem in a manner which would resemble an application in actual use. Since a great many switchboard and control equipment operators are seated at their jobs, and since it was desired that the effects of physical differences be minimized³, the test operators were seated.

Before beginning the test, each operator was asked to fill out an operator data sheet. This data sheet, shown in Appendix C, Figure 8, was used to insure that all operators were free of abnormalities which might affect the results and to aid in tracing down any inconsistencies in operator performance which might develop.

When the sheet had been filled out, the operator was asked to be seated in the test chair. He was then asked to hold his upper arm vertical and against his side with his forearm extended at right angles to it. The chair was moved so that the tips of the operator's fingers just touched the edge of the table. The height of the panel was adjusted by means of blocks so that the elbow of the operator, with his arm in the position just described, was ten inches below the centerline of the switches.

3. For a discussion of physical differences, see Tufts College Institute for Applied Psychology, Handbook of Human Engineering Data, parts I and II, Medford, Mass., 1949.

1. The first of these is the fact that the Commission has not yet received any information from the Government of the United Kingdom regarding the proposed changes to the law of the United Kingdom in relation to the treatment of the British Commonwealth countries.

The operator was then asked to identify the colored stripes as the colors were named, in order to eliminate any operators who might be color blind. After this check, the operator was asked to position each switch in the red (60 degree) position, starting with the left-hand switch and using only his right hand. The left hand was not used so that all operators would have the same motion pattern and to eliminate the effects of two-handed operation. In order to eliminate the possibility of becoming familiar with one shape of handle, each switch was provided with a differently-shaped handle for the test run.⁴

The regular runs were then commenced and were presented in a previously-designed random order as shown in Appendix C, Figure 9. The position of the operator at the beginning of each run was erect in the chair with his hands in his lap. The following set of instructions was read to the operator: "The position to which the switches are to be rotated will be designated by color. You will use only your right hand and rotate the switches only in the clockwise direction. You will start with the left-hand switch and operate the switches from left to right. You are to position each switch accurately in the designated position as rapidly as possible. Accuracy is of prime importance, but you should work as rapidly as you think you can without making errors."

4. For a discussion of the psychological aspects of this procedure, see Chapanis, A.R., Garner, W.R., and Morgan, J.T., Applied Experimental Psychology, New York, John Wiley & Sons, Inc., 1949.

1. The first step in the process of identifying a problem is to define the problem. This involves identifying the symptoms of the problem and determining the scope of the problem. Once the problem has been defined, the next step is to identify the causes of the problem. This involves identifying the factors that are contributing to the problem and determining the relationships between these factors. Once the causes of the problem have been identified, the next step is to develop a plan of action. This involves identifying the steps that need to be taken to solve the problem and determining the resources that will be needed to implement the plan. Once a plan of action has been developed, the final step is to implement the plan. This involves carrying out the steps that have been identified in the plan and monitoring the progress of the implementation.

THE REPORTS OF THE UNITED STATES DEPARTMENT OF THE INTERIOR, BUREAU OF LAND MANAGEMENT, WASHINGTON, D. C., 1964.

The desired position of the switches was designated by color and the operator was given the oral order, "Begin". He then raised his right hand from his lap and advanced it to the left-hand switch. The switches were operated from left to right and in a clockwise direction of rotation. At the completion of the run on each handle, the operator was asked to relax in the chair while the next handle to be presented was installed on the panel.

Each operator was required to make three complete runs and the average of the times was computed to be used for analysis purposes. Each of the three runs was identical. That is, the operator was presented with the complete sequence of five handles and four angles (as shown on the sample data sheet in Appendix C, Figure 9) three successive times.

THESE RESULTS INDICATE THAT THE SYSTEM IS CAPABLE OF

PERFORMING THE REQUIRED FUNCTIONS WITH A HIGH DEGREE OF
ACCURACY AND RELIABILITY. THE RESULTS OF THE TESTS
CONDUCTED TO DATE HAVE BEEN MOST SATISFACTORY. THE
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CONDUCTED TO DATE HAVE BEEN MOST SATISFACTORY.

RESULTS

The overall average times obtained from this investigation are shown in Table 1 below. The individual operator's average times are shown in Table 2. The actual time values obtained for all operators for all handles are given in Appendix A, Tables 3, 4 and 5.

	30°	60°	90°	120°
Handle 1	189.6	225.9	239.0	300.3
Handle 2	174.8	222.8	240.3	281.3
Handle 3	199.2	233.3	276.0	317.1
Handle 4	187.4	221.0	251.7	296.8
Handle 5	186.6	236.5	275.5	315.0

Table 1.

Overall average times.
(In hundredths of a second.)

An examination of Table 1 shows that handle #2 required the least time for all angles of rotation except 60°. Handle #4 required the least time for 60° and the second lowest time for 90° and 120°. Handle #3 required the most time for all angles except 60° where it required next to the highest time.

Curves based upon the data contained in Table 1 are shown in Figure 7. The curves were fitted by the method of least squares and the equations are given in Appendix B. Examination of the curves shows that, for all angles of

Handle #1Handle #2

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	233	240	261	326	1	194	233	252	284
2	223	223	234	269	2	184	248	286	295
3	172	213	236	311	3	168	199	221	311
4	207	233	249	312	4	155	228	275	301
5	183	220	290	309	5	176	274	261	291
6	173	233	242	288	6	152	197	202	225
7	203	232	290	336	7	203	261	252	291
8	164	209	247	247	8	167	215	227	317
9	209	234	295	363	9	187	231	229	306
10	146	189	203	264	10	155	195	195	230
11	215	267	299	342	11	204	260	279	318
12	172	205	238	279	12	137	178	208	271
13	151	167	226	217	13	147	172	191	209
14	188	226	255	278	14	172	222	207	282
15	206	217	322	362	15	191	230	270	288

Table 2.

Average time values for all runs.

(In hundredths of a second)

[illegible]

Handle #3Handle #4

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	262	301	347	370	1	212	241	255	327
2	216	252	305	308	2	239	219	262	290
3	196	215	251	306	3	164	201	211	267
4	224	236	338	373	4	180	216	240	351
5	254	252	323	309	5	171	234	247	307
6	192	207	268	314	6	174	250	232	267
7	203	258	286	326	7	200	247	291	358
8	153	227	276	374	8	161	197	232	295
9	174	223	255	336	9	221	250	261	318
10	153	190	210	283	10	159	180	226	255
11	215	315	297	351	11	222	262	325	325
12	167	197	254	290	12	171	194	239	274
13	181	172	209	223	13	149	160	210	219
14	202	222	245	292	14	177	218	242	279
15	197	233	271	304	15	211	247	303	320

Table 2.
(Continued)

Table 1

Table 2

α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}	α_{13}	α_{14}	α_{15}	α_{16}	α_{17}	α_{18}	α_{19}	α_{20}	α_{21}	α_{22}	α_{23}	α_{24}	α_{25}	α_{26}	α_{27}	α_{28}	α_{29}	α_{30}	α_{31}	α_{32}	α_{33}	α_{34}	α_{35}	α_{36}	α_{37}	α_{38}	α_{39}	α_{40}	α_{41}	α_{42}	α_{43}	α_{44}	α_{45}	α_{46}	α_{47}	α_{48}	α_{49}	α_{50}	α_{51}	α_{52}	α_{53}	α_{54}	α_{55}	α_{56}	α_{57}	α_{58}	α_{59}	α_{60}	α_{61}	α_{62}	α_{63}	α_{64}	α_{65}	α_{66}	α_{67}	α_{68}	α_{69}	α_{70}	α_{71}	α_{72}	α_{73}	α_{74}	α_{75}	α_{76}	α_{77}	α_{78}	α_{79}	α_{80}	α_{81}	α_{82}	α_{83}	α_{84}	α_{85}	α_{86}	α_{87}	α_{88}	α_{89}	α_{90}	α_{91}	α_{92}	α_{93}	α_{94}	α_{95}	α_{96}	α_{97}	α_{98}	α_{99}	α_{100}
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192	193	194	195	196	197	198	199	200
201	202	203	204	205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298	299	300
301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320	321	322	323	324	325	326	327	328	329	330	331	332	333	334	335	336	337	338	339	340	341	342	343	344	345	346	347	348	349	350	351	352	353	354	355	356	357	358	359	360	361	362	363	364	365	366	367	368	369	370	371	372	373	374	375	376	377	378	379	380	381	382	383	384	385	386	387	388	389	390	391	392	393	394	395	396	397	398	399	400
401	402	403	404	405	406	407	408	409	410	411	412	413	414	415	416	417	418	419	420	421	422	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437	438	439	440	441	442	443	444	445	446	447	448	449	450	451	452	453	454	455	456	457	458	459	460	461	462	463	464	465	466	467	468	469	470	471	472	473	474	475	476	477	478	479	480	481	482	483	484	485	486	487	488	489	490	491	492	493	494	495	496	497	498	499	500
501	502	503	504	505	506	507	508	509	510	511	512	513	514	515	516	517	518	519	520	521	522	523	524	525	526	527	528	529	530	531	532	533	534	535	536	537	538	539	540	541	542	543	544	545	546	547	548	549	550	551	552	553	554	555	556	557	558	559	560	561	562	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579	580	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600
601	602	603	604	605	606	607	608	609	610	611	612	613	614	615	616	617	618	619	620	621	622	623	624	625	626	627	628	629	630	631	632	633	634	635	636	637	638	639	640	641	642	643	644	645	646	647	648	649	650	651	652	653	654	655	656	657	658	659	660	661	662	663	664	665	666	667	668	669	670	671	672	673	674	675	676	677	678	679	680	681	682	683	684	685	686	687	688	689	690	691	692	693	694	695	696	697	698	699	700
701	702	703	704	705	706	707	708	709	710	711	712	713	714	715	716	717	718	719	720	721	722	723	724	725	726	727	728	729	730	731	732	733	734	735	736	737	738	739	740	741	742	743	744	745	746	747	748	749	750	751	752	753	754	755	756	757	758	759	760	761	762	763	764	765	766	767	768	769	770	771	772	773	774	775	776	777	778	779	780	781	782	783	784	785	786	787	788	789	790	791	792	793	794	795	796	797	798	799	800
801	802	803	804	805	806	807	808	809	810	811	812	813	814	815	816	817	818	819	820	821	822	823	824	825	826	827	828	829	830	831	832	833	834	835	836	837	838	839	840	841	842	843	844	845	846	847	848	849	850	851	852	853	854	855	856	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900
901	902	903	904	905	906	907	908	909	910	911	912	913	914	915	916	917	918	919	920	921	922	923	924	925	926	927	928	929	930	931	932	933	934	935	936	937	938	939	940	941	942	943	944	945	946	947	948	949	950	951	952	953	954	955	956	957	958	959	960	961	962	963	964	965	966	967	968	969	970	971	972	973	974	975	976	977	978	979	980	981	982	983	984	985	986	987	988	989	990	991	992	993	994	995	996	997	998	999	1000

Table 1
(continued)

Handle #5

Oper. No.	30°	60°	90°	120°
1	220	302	308	338
2	218	243	285	280
3	178	213	286	276
4	210	231	266	353
5	205	253	269	356
6	177	235	256	285
7	212	289	352	397
8	163	204	253	311
9	173	269	254	303
10	151	179	220	273
11	208	298	334	349
12	164	214	267	302
13	147	171	235	209
14	169	218	245	306
15	202	235	286	326

Table 2.

(Continued)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
1998	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
1999	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2001	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2002	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2003	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2004	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2005	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2006	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2007	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2008	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2009	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2010	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2011	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2012	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2013	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2014	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2015	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2016	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2017	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2018	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2019	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000
2020	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	12000

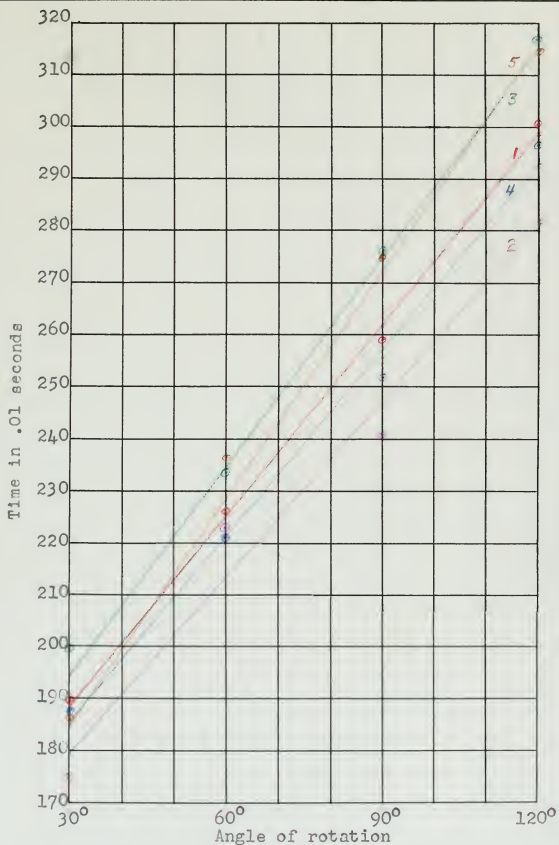


Fig. 7

Operating times vs. angles of rotation for switch handles
(best-fitting curves)

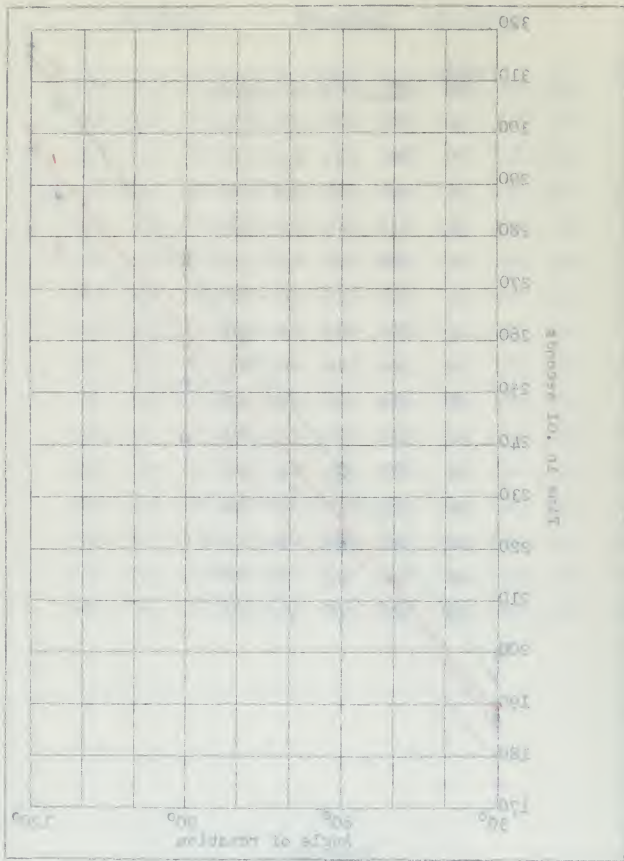


Fig. 7

Operating time vs. angle of rotation for various loads
(best-fitting curve)

rotation, handle #2 required the least time and handle #4 required the second lowest time. The other three handles required the highest times.

A statistical analysis of the data (see Appendix B, Table 10) obtained for each of the individual angles of rotation showed significant variances among operators and among handles. The variance among operators was consistently much higher than that among handles, which was to be expected due to individual differences in people.

For the complete data (see Appendix B, Table 11), the variances among handles and the variances among operators, for all angles of rotation, were highly significant. The overall variance among angles of rotation was highly significant although the interaction among handles and angles of rotation was significant only above the 5% level. The interaction among operators and handles and the interaction among operators and angles of rotation were both significant. The significances mentioned above are all at the 1% level unless otherwise stated.

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CONCLUSIONS

The analysis of the data indicates that there is an optimum shape of handle for minimum operating time for switches under the conditions prevalent in this investigation. An examination of the plotted data leads to the belief that, in those situations requiring turning a switch handle to a specific point, the round shaped handle provides for the highest operating times while the generally rectangular shape provides for the lowest times. It is probable that those shapes more nearly resembling a pointer provide a better indication of position than the round shape with only an index mark.

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APPENDIX A.

TIMES REQUIRED BY EACH OPERATOR
TO PERFORM THE SWITCHING OPERATIONS

BY ORDER

DEPARTMENT OF THE ARMY
WASHINGTON, D. C.

Handle #1Handle #2

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	270	283	307	421	1	225	270	311	319
2	174	220	211	278	2	203	243	361	313
3	179	206	230	284	3	166	202	238	261
4	206	244	253	347	4	104	251	353	368
5	189	252	274	292	5	178	284	293	348
6	180	261	308	308	6	169	205	208	241
7	205	230	303	323	7	209	239	246	283
8	169	204	250	225	8	180	235	242	323
9	231	300	323	443	9	174	233	215	340
10	164	211	227	279	10	155	199	190	194
11	216	256	312	323	11	222	283	507	347
12	214	195	231	299	12	163	187	218	274
13	152	208	211	209	13	140	162	205	208
14	191	234	233	302	14	120	239	211	302
15	211	224	372	336	15	193	230	253	334

Table 3.

Time values for first run.

(In hundredths of a second)

Table 1

Table 2

λ_{11}	λ_{12}	λ_{21}	λ_{22}	$\lambda_{11} + \lambda_{22}$	λ_{11}	λ_{12}	λ_{21}	λ_{22}	$\lambda_{11} + \lambda_{22}$
1.1	1.1	1.1	1.1	2.2	1.1	1.1	1.1	1.1	2.2
1.2	1.2	1.2	1.2	2.4	1.2	1.2	1.2	1.2	2.4
1.3	1.3	1.3	1.3	2.6	1.3	1.3	1.3	1.3	2.6
1.4	1.4	1.4	1.4	2.8	1.4	1.4	1.4	1.4	2.8
1.5	1.5	1.5	1.5	3.0	1.5	1.5	1.5	1.5	3.0
1.6	1.6	1.6	1.6	3.2	1.6	1.6	1.6	1.6	3.2
1.7	1.7	1.7	1.7	3.4	1.7	1.7	1.7	1.7	3.4
1.8	1.8	1.8	1.8	3.6	1.8	1.8	1.8	1.8	3.6
1.9	1.9	1.9	1.9	3.8	1.9	1.9	1.9	1.9	3.8
2.0	2.0	2.0	2.0	4.0	2.0	2.0	2.0	2.0	4.0
2.1	2.1	2.1	2.1	4.2	2.1	2.1	2.1	2.1	4.2
2.2	2.2	2.2	2.2	4.4	2.2	2.2	2.2	2.2	4.4
2.3	2.3	2.3	2.3	4.6	2.3	2.3	2.3	2.3	4.6
2.4	2.4	2.4	2.4	4.8	2.4	2.4	2.4	2.4	4.8
2.5	2.5	2.5	2.5	5.0	2.5	2.5	2.5	2.5	5.0
2.6	2.6	2.6	2.6	5.2	2.6	2.6	2.6	2.6	5.2
2.7	2.7	2.7	2.7	5.4	2.7	2.7	2.7	2.7	5.4
2.8	2.8	2.8	2.8	5.6	2.8	2.8	2.8	2.8	5.6
2.9	2.9	2.9	2.9	5.8	2.9	2.9	2.9	2.9	5.8
3.0	3.0	3.0	3.0	6.0	3.0	3.0	3.0	3.0	6.0

Table 3

Table 3 shows the results of the
 (Table 3) (Table 3) (Table 3)

Handle #3Handle #4

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	280	343	335	413	1	240	299	305	398
2	164	235	336	284	2	204	211	243	257
3	222	233	238	271	3	177	195	220	261
4	294	247	441	437	4	184	231	259	361
5	198	312	300	335	5	183	262	290	352
6	183	276	367	280	6	202	321	267	312
7	203	270	293	344	7	204	256	289	379
8	152	246	238	397	8	180	179	252	261
9	192	222	247	327	9	236	278	253	362
10	159	214	228	314	10	169	175	232	279
11	209	312	306	363	11	232	259	343	360
12	156	215	290	288	12	153	195	261	236
13	234	190	233	272	13	154	159	226	229
14	243	214	215	265	14	192	215	250	275
15	200	225	278	332	15	204	220	344	355

Table 3.

(Continued)

Handle #5

Oper. No.	30°	60°	90°	120°
1	231	308	331	436
2	244	227	309	260
3	206	222	295	269
4	193	267	274	339
5	180	253	300	356
6	189	263	312	338
7	208	313	367	433
8	159	194	278	275
9	191	255	229	273
10	159	203	237	264
11	219	236	352	374
12	171	211	264	263
13	141	170	211	210
14	169	227	292	375
15	200	238	295	335

Table 3.

(Continued)

Table 1. Summary of data

Year	Month	Day	Time	Lat	Long	Depth	Temp	Sal
1998	10	10	08:00	24.5	118.5	100	28.5	35.0
1998	10	10	09:00	24.5	118.5	100	28.5	35.0
1998	10	10	10:00	24.5	118.5	100	28.5	35.0
1998	10	10	11:00	24.5	118.5	100	28.5	35.0
1998	10	10	12:00	24.5	118.5	100	28.5	35.0
1998	10	10	13:00	24.5	118.5	100	28.5	35.0
1998	10	10	14:00	24.5	118.5	100	28.5	35.0
1998	10	10	15:00	24.5	118.5	100	28.5	35.0
1998	10	10	16:00	24.5	118.5	100	28.5	35.0
1998	10	10	17:00	24.5	118.5	100	28.5	35.0
1998	10	10	18:00	24.5	118.5	100	28.5	35.0
1998	10	10	19:00	24.5	118.5	100	28.5	35.0
1998	10	10	20:00	24.5	118.5	100	28.5	35.0
1998	10	10	21:00	24.5	118.5	100	28.5	35.0
1998	10	10	22:00	24.5	118.5	100	28.5	35.0
1998	10	10	23:00	24.5	118.5	100	28.5	35.0
1998	10	10	00:00	24.5	118.5	100	28.5	35.0
1998	10	10	01:00	24.5	118.5	100	28.5	35.0
1998	10	10	02:00	24.5	118.5	100	28.5	35.0
1998	10	10	03:00	24.5	118.5	100	28.5	35.0
1998	10	10	04:00	24.5	118.5	100	28.5	35.0
1998	10	10	05:00	24.5	118.5	100	28.5	35.0
1998	10	10	06:00	24.5	118.5	100	28.5	35.0
1998	10	10	07:00	24.5	118.5	100	28.5	35.0

2000-2001

1999-2000

Handle #1Handle #2

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	233	239	249	264	1	138	210	233	260
2	193	218	248	269	2	194	276	226	321
3	172	214	241	364	3	164	199	221	343
4	227	239	262	310	4	180	228	240	303
5	194	316	263	302	5	191	292	324	265
6	172	213	230	300	6	147	194	200	205
7	190	216	290	317	7	205	311	280	301
8	147	195	219	213	8	175	222	220	303
9	176	197	230	286	9	198	228	242	292
10	143	171	212	280	10	156	219	231	286
11	218	275	289	374	11	202	244	273	289
12	149	228	269	295	12	124	174	220	270
13	157	177	231	227	13	163	187	197	215
14	197	229	261	275	14	170	224	206	290
15	212	213	326	497	15	180	252	276	271

Table 4.

Time values for second run.

(In hundredths of a second)

Handle #3Handle #4

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	279	263	335	359	1	204	201	223	350
2	303	287	316	326	2	307	229	291	290
3	184	204	241	261	3	161	199	202	257
4	185	221	266	353	4	169	203	214	321
5	323	224	293	323	5	162	225	224	313
6	214	169	209	288	6	166	225	224	268
7	217	260	280	307	7	203	219	224	359
8	131	237	289	355	8	151	196	228	274
9	167	224	273	399	9	193	220	264	282
10	161	168	215	292	10	167	192	212	243
11	195	272	284	341	11	203	269	323	319
12	165	196	243	281	12	153	225	234	234
13	157	159	204	200	13	147	162	180	210
14	176	223	260	321	14	176	207	259	311
15	192	247	296	265	15	220	234	284	294

Table 4.

(Continued)

TABLE 1

TABLE 2

λ_{100}	λ_{50}	λ_{25}	λ_{10}	λ_{5}	λ_{100}	λ_{50}	λ_{25}	λ_{10}	λ_{5}
0.01	0.02	0.05	0.10	0.20	0.01	0.02	0.05	0.10	0.20
0.02	0.04	0.08	0.15	0.30	0.02	0.04	0.08	0.15	0.30
0.03	0.06	0.12	0.25	0.50	0.03	0.06	0.12	0.25	0.50
0.04	0.08	0.16	0.35	0.70	0.04	0.08	0.16	0.35	0.70
0.05	0.10	0.20	0.45	0.90	0.05	0.10	0.20	0.45	0.90
0.06	0.12	0.24	0.55	1.10	0.06	0.12	0.24	0.55	1.10
0.07	0.14	0.28	0.65	1.30	0.07	0.14	0.28	0.65	1.30
0.08	0.16	0.32	0.75	1.50	0.08	0.16	0.32	0.75	1.50
0.09	0.18	0.36	0.85	1.70	0.09	0.18	0.36	0.85	1.70
0.10	0.20	0.40	0.95	1.90	0.10	0.20	0.40	0.95	1.90
0.12	0.24	0.48	1.10	2.20	0.12	0.24	0.48	1.10	2.20
0.14	0.28	0.56	1.25	2.50	0.14	0.28	0.56	1.25	2.50
0.16	0.32	0.64	1.40	2.80	0.16	0.32	0.64	1.40	2.80
0.18	0.36	0.72	1.55	3.10	0.18	0.36	0.72	1.55	3.10
0.20	0.40	0.80	1.70	3.40	0.20	0.40	0.80	1.70	3.40
0.22	0.44	0.88	1.85	3.70	0.22	0.44	0.88	1.85	3.70
0.24	0.48	0.96	2.00	4.00	0.24	0.48	0.96	2.00	4.00
0.26	0.52	1.04	2.15	4.30	0.26	0.52	1.04	2.15	4.30
0.28	0.56	1.12	2.30	4.60	0.28	0.56	1.12	2.30	4.60
0.30	0.60	1.20	2.45	4.90	0.30	0.60	1.20	2.45	4.90

TABLE 3

TABLE 4

TABLE 5

Hamble #5

Oper. No.	30°	60°	90°	120°
1	211	286	278	368
2	198	263	303	307
3	172	200	307	274
4	269	210	272	325
5	191	235	310	401
6	176	249	228	289
7	215	294	354	335
8	149	214	240	264
9	166	261	289	335
10	164	184	221	268
11	204	304	352	368
12	174	240	267	319
13	150	174	282	220
14	164	214	226	279
15	215	264	312	363

Table 4.

(Continued)

TABLE 1

Year	Age	Sex	Weight (kg)	Length (cm)	Wing (cm)	Tail (cm)	Beak (mm)	Foot (mm)	Claw (mm)
1961	10	M	100	375	115	115	15	15	15
1961	10	F	95	370	110	110	15	15	15
1961	10	M	105	380	120	120	15	15	15
1961	10	F	90	365	105	105	15	15	15
1961	10	M	110	385	125	125	15	15	15
1961	10	F	85	360	100	100	15	15	15
1961	10	M	115	390	130	130	15	15	15
1961	10	F	80	355	95	95	15	15	15
1961	10	M	120	395	135	135	15	15	15
1961	10	F	75	350	90	90	15	15	15
1961	10	M	125	400	140	140	15	15	15
1961	10	F	70	345	85	85	15	15	15
1961	10	M	130	405	145	145	15	15	15
1961	10	F	65	340	80	80	15	15	15
1961	10	M	135	410	150	150	15	15	15
1961	10	F	60	335	75	75	15	15	15
1961	10	M	140	415	155	155	15	15	15
1961	10	F	55	330	70	70	15	15	15
1961	10	M	145	420	160	160	15	15	15
1961	10	F	50	325	65	65	15	15	15
1961	10	M	150	425	165	165	15	15	15
1961	10	F	45	320	60	60	15	15	15
1961	10	M	155	430	170	170	15	15	15
1961	10	F	40	315	55	55	15	15	15
1961	10	M	160	435	175	175	15	15	15
1961	10	F	35	310	50	50	15	15	15
1961	10	M	165	440	180	180	15	15	15
1961	10	F	30	305	45	45	15	15	15
1961	10	M	170	445	185	185	15	15	15
1961	10	F	25	300	40	40	15	15	15
1961	10	M	175	450	190	190	15	15	15
1961	10	F	20	295	35	35	15	15	15
1961	10	M	180	455	195	195	15	15	15
1961	10	F	15	290	30	30	15	15	15
1961	10	M	185	460	200	200	15	15	15
1961	10	F	10	285	25	25	15	15	15
1961	10	M	190	465	205	205	15	15	15
1961	10	F	5	280	20	20	15	15	15
1961	10	M	195	470	210	210	15	15	15
1961	10	F	0	275	15	15	15	15	15

TABLE 1
(Continued)

Handle #1Handle #2

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	190	197	227	274	1	168	220	211	274
2	303	231	244	261	2	162	226	272	251
3	165	219	237	263	3	175	197	205	330
4	188	217	232	279	4	169	212	225	238
5	177	271	332	332	5	159	245	226	261
6	167	225	189	256	6	140	191	196	230
7	213	251	275	371	7	194	232	279	289
8	176	228	271	302	8	167	189	219	324
9	170	205	271	359	9	194	232	229	287
10	130	185	170	234	10	155	176	164	210
11	210	271	295	330	11	188	253	252	319
12	152	192	213	244	12	124	172	166	269
13	143	176	236	216	13	137	169	172	204
14	175	214	245	257	14	167	202	223	254
15	196	213	267	252	15	201	207	250	259

Table 5.

Time values for third run.

(In hundredths of a second)

Page	Page	Page	Page	Page	Page	Page	Page	Page	Page
100	110	120	130	140	150	160	170	180	190
200	210	220	230	240	250	260	270	280	290
300	310	320	330	340	350	360	370	380	390
400	410	420	430	440	450	460	470	480	490
500	510	520	530	540	550	560	570	580	590
600	610	620	630	640	650	660	670	680	690
700	710	720	730	740	750	760	770	780	790
800	810	820	830	840	850	860	870	880	890
900	910	920	930	940	950	960	970	980	990

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Handle #3Handle #4

Oper. No.	30°	60°	90°	120°	Oper. No.	30°	60°	90°	120°
1	227	291	372	339	1	192	232	237	242
2	180	235	262	309	2	205	218	246	322
3	182	208	273	385	3	153	209	212	282
4	194	239	307	329	4	136	215	246	370
5	180	221	390	269	5	168	214	228	257
6	179	176	227	374	6	155	203	204	221
7	190	244	285	328	7	191	265	301	337
8	156	198	300	371	8	151	215	216	329
9	173	222	245	281	9	232	252	261	311
10	140	198	186	242	10	140	175	225	242
11	240	361	302	349	11	231	259	305	295
12	180	180	228	301	12	197	161	221	253
13	153	167	189	198	13	145	159	167	218
14	181	230	261	290	14	163	233	216	253
15	200	227	238	316	15	209	237	262	312

Table 5.

(Continued)

Table 1

Table 2

Year	Q1	Q2	Q3	Q4	Year	Q1	Q2	Q3	Q4	Year
2011	100	100	100	100	1	100	100	100	100	1
2012	100	100	100	100	2	100	100	100	100	2
2013	100	100	100	100	3	100	100	100	100	3
2014	100	100	100	100	4	100	100	100	100	4
2015	100	100	100	100	5	100	100	100	100	5
2016	100	100	100	100	6	100	100	100	100	6
2017	100	100	100	100	7	100	100	100	100	7
2018	100	100	100	100	8	100	100	100	100	8
2019	100	100	100	100	9	100	100	100	100	9
2020	100	100	100	100	10	100	100	100	100	10
2021	100	100	100	100	11	100	100	100	100	11
2022	100	100	100	100	12	100	100	100	100	12
2023	100	100	100	100	13	100	100	100	100	13
2024	100	100	100	100	14	100	100	100	100	14
2025	100	100	100	100	15	100	100	100	100	15
2026	100	100	100	100	16	100	100	100	100	16
2027	100	100	100	100	17	100	100	100	100	17
2028	100	100	100	100	18	100	100	100	100	18
2029	100	100	100	100	19	100	100	100	100	19
2030	100	100	100	100	20	100	100	100	100	20

Table 1

Table 2

Table 3

Handle #3

Oper. No.	30°	60°	90°	120°
1	219	313	280	359
2	211	240	242	272
3	157	217	253	286
4	169	215	252	400
5	245	272	255	310
6	166	203	223	227
7	214	259	336	424
8	186	204	240	394
9	162	290	244	299
10	129	150	203	286
11	200	273	297	306
12	146	190	271	323
13	151	170	212	197
14	173	213	217	263
15	191	202	249	280

Table 3.

(Continued)

Table 1

Year	Age	Sex	Weight (kg)	Length (cm)	Wing (cm)	Tail (cm)	Beak (mm)	Foot (mm)	Claw (mm)
1950	1	M	800	140	110	80	10	15	5
1951	2	F	750	135	105	75	9	14	4
1952	3	M	820	145	115	85	11	16	6
1953	4	F	780	140	110	80	10	15	5
1954	5	M	850	150	120	90	12	17	7
1955	6	F	800	145	115	85	11	16	6
1956	7	M	880	155	125	95	13	18	8
1957	8	F	830	150	120	90	12	17	7
1958	9	M	900	160	130	100	14	19	9
1959	10	F	850	155	125	95	13	18	8
1960	11	M	920	165	135	105	15	20	10
1961	12	F	870	160	130	100	14	19	9
1962	13	M	950	170	140	110	16	21	11
1963	14	F	900	165	135	105	15	20	10
1964	15	M	980	175	145	115	17	22	12
1965	16	F	930	170	140	110	16	21	11
1966	17	M	1000	180	150	120	18	23	13
1967	18	F	950	175	145	115	17	22	12

Table 1
[Continued]

APPENDIX B.
CALCULATIONS USED IN
THE EVALUATION OF THE DATA

For the purpose of analysis, the data in Table 2 were separated for each angle of rotation. The data in each group were simplified for computation by subtracting the same amount from each value in the group and arranged as shown in tables 6, 7, 8 and 9.

Each column was then totaled and the individual column totals labeled X_1, X_2, X_3, X_4 , and X_5 . The grand total of all data in the table was labeled Z . Each value in the table was squared and the sum of the squares labeled T^2 . Each row was totaled and the individual row totals labeled Y_1, Y_2, Y_3 , and so on up to Y_{15} .

The total variation, Q , was computed by means of the formula $Q = T^2 - \frac{Z^2}{km}$, where k is the number of columns and m is the number of rows.

The variation among column means, Q_c , was computed by means of the formula $Q_c = \frac{1}{m} (X_1^2 + X_2^2 + X_3^2 + X_4^2 + X_5^2) - \frac{Z^2}{km}$.

The variation among row means, Q_r , was computed by means of the formula $Q_r = \frac{1}{k} (Y_1^2 + Y_2^2 + Y_3^2 \dots + Y_{15}^2) - \frac{Z^2}{km}$.

The residual variation, Q_e , was computed by means of the formula $Q_e = Q - Q_c - Q_r$.

The column to column variance, σ_c^2 , was computed by means of the formula $\sigma_c^2 = Q_c \div (k-1)$. The row to row variance, σ_r^2 , was computed by means of the formula $\sigma_r^2 = Q_r \div (m-1)$. The residual variance, σ_e^2 , was computed by means of the formula $\sigma_e^2 = Q_e \div (k-1)(m-1)$.

For the purpose of analysis, the data in Table 2

were segregated for each range of variation. The data in each group were classified for comparison by transferring the same amount from each value in the group and arranged as shown in Tables 3, 4, 5 and 6.

Each column was then totaled and the individual

columns totaled labeled Σ_1 , Σ_2 , Σ_3 , Σ_4 , and Σ_5 . The grand total of all data in the table was labeled Σ . Each value in the table was weighted and the sum of the weights labeled ΣW . Each row was totaled and the individual row totals labeled Σ_1 , Σ_2 , Σ_3 , Σ_4 , and Σ_5 as in Table 3.

The total variation, σ^2 , was computed by means of

the formula $\sigma^2 = \frac{\Sigma W^2}{\Sigma W} - \frac{(\Sigma W)^2}{(\Sigma W)^2}$, where ΣW is the amount of column and ΣW^2 is the number of rows.

The variation among column means, σ_c^2 , was computed

by means of the formula $\sigma_c^2 = \frac{1}{\Sigma W} (\Sigma W^2 + \frac{\Sigma W^2}{2} + \frac{\Sigma W^2}{3} + \frac{\Sigma W^2}{4} + \frac{\Sigma W^2}{5}) - \frac{(\Sigma W)^2}{(\Sigma W)^2}$.

The variation among row means, σ_r^2 , was computed by

means of the formula $\sigma_r^2 = \frac{1}{\Sigma W} (\Sigma W^2 + \frac{\Sigma W^2}{2} + \frac{\Sigma W^2}{3} + \frac{\Sigma W^2}{4} + \frac{\Sigma W^2}{5}) - \frac{(\Sigma W)^2}{(\Sigma W)^2}$.

The residual variation, σ_d^2 , was computed by means

of the formula $\sigma_d^2 = \sigma^2 - \sigma_c^2 - \sigma_r^2$.

The column to column variance, σ_c^2 , was computed

by means of the formula $\sigma_c^2 = \frac{1}{\Sigma W} (2-1)$. The row to row

variance, σ_r^2 , was computed by means of the formula

$\sigma_r^2 = \frac{1}{\Sigma W} (2-1)$. The residual variance, σ_d^2 , was computed

by means of the formula $\sigma_d^2 = \sigma^2 - \sigma_c^2 - \sigma_r^2$.

The F values for the variances between rows and between columns were computed by dividing the variances, respectively, by the residual variance. These F values were then compared with the $F_{.05}$ and $F_{.01}$ values from a table of F distribution for the proper degrees of freedom⁵.

In like manner the variation, variance, and F values for total variation among handles, total variation among operators, total variation among angles of rotation, interaction between handles and angles of rotation, interaction between operators and handles, and interaction between operators and angles of rotation were computed and compared with the F -distribution table. All computed values are given in Tables 10 and 11.

The average times required by all operators for each handle and for each angle of rotation were computed. Equations for lines of best fit to the data were computed by the method of least squares and were plotted as shown in Figure 7. The computed equations are:

Handle #1	$y = 18.952 + 1.218 x$
Handle #2	$y = 9.505 + 1.130 x$
Handle #3	$y = 24.320 + 1.343 x$
Handle #4	$y = 15.417 + 1.196 x$
Handle #5	$y = 15.053 + 1.454 x$

5. Snedecor, G.W., *Statistical Methods Applied to Experiments in Agriculture and Biology*, Ames, Iowa, Collegiate Press, 1934.

The 7 values for the parameters between 100 and

between columns were weighted by dividing the parameter

weightings by the typical variance. Thus 7 values were

then averaged into the 7, 11, 15, 19, 23, 27, and 31

5 distributions for the present analysis of variance.

15 like means for variance, variance, and 5

values for each variance mean. Each variance

mean represents total variance mean within 5 variance

intervals between means and within 5 variance

intervals between means and within 5 variance

intervals and means of variance were weighted and averaged

with the distribution mean. All variance means were

given the value 10 and 11.

The means given by all variance for

each mean and for each mean of variance were weighted

by the value of each mean and were divided as shown

in Figure 7. The weighted variance mean

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

variance 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31

Oper. No.	Handle					EY	EY ²
	1	2	3	4	5		
1	96	57	125	75	83	436	40604
2	86	47	79	102	81	395	32811
3	35	31	59	27	41	193	8077
4	70	48	87	43	73	321	21951
5	46	39	117	34	63	304	23106
6	36	15	55	37	40	183	7515
7	66	68	68	63	75	336	22462
8	27	30	16	24	28	125	3245
9	72	50	57	84	36	279	17405
10	9	16	16	22	14	79	1341
11	78	67	78	65	71	379	23923
12	35	0	30	34	27	126	4010
13	14	10	44	12	10	90	2476
14	51	35	65	40	32	223	10873
15	69	54	60	74	65	322	20978
EX	790	567	934	756	744	3791	
EX ²	51366	27279	72612	49818	45704		245779

Table 6.

Computation data for 30° rotation.

a. (Contd.)

α_{10}	TV	0	1	2	3	4	α_{100}
0.0000	0.00	00	00	00.0	00	00	0
0.0001	0.01	00	00.1	00	00	00	1
0.0002	0.02	00	00	00.2	00	00	2
0.0003	0.03	00	00	00.3	00	00	3
0.0004	0.04	00	00	00.4	00	00	4
0.0005	0.05	00	00	00.5	00	00	5
0.0006	0.06	00	00	00.6	00	00	6
0.0007	0.07	00	00	00.7	00	00	7
0.0008	0.08	00	00	00.8	00	00	8
0.0009	0.09	00	00	00.9	00	00	9
0.0010	0.10	00	00	01	00	00	10
0.0011	0.11	00	00.1	01	00	00	11
0.0012	0.12	00	00.2	01	00	00	12
0.0013	0.13	00	00.3	01	00	00	13
0.0014	0.14	00	00.4	01	00	00	14
0.0015	0.15	00	00.5	01	00	00	15
0.0016	0.16	00	00.6	01	00	00	16
0.0017	0.17	00	00.7	01	00	00	17
0.0018	0.18	00	00.8	01	00	00	18
0.0019	0.19	00	00.9	01	00	00	19
0.0020	0.20	00	01	00	00	00	20
0.0021	0.21	00	01.1	00	00	00	21
0.0022	0.22	00	01.2	00	00	00	22
0.0023	0.23	00	01.3	00	00	00	23
0.0024	0.24	00	01.4	00	00	00	24
0.0025	0.25	00	01.5	00	00	00	25
0.0026	0.26	00	01.6	00	00	00	26
0.0027	0.27	00	01.7	00	00	00	27
0.0028	0.28	00	01.8	00	00	00	28
0.0029	0.29	00	01.9	00	00	00	29
0.0030	0.30	00	02	00	00	00	30
0.0031	0.31	00	02.1	00	00	00	31
0.0032	0.32	00	02.2	00	00	00	32
0.0033	0.33	00	02.3	00	00	00	33
0.0034	0.34	00	02.4	00	00	00	34
0.0035	0.35	00	02.5	00	00	00	35
0.0036	0.36	00	02.6	00	00	00	36
0.0037	0.37	00	02.7	00	00	00	37
0.0038	0.38	00	02.8	00	00	00	38
0.0039	0.39	00	02.9	00	00	00	39
0.0040	0.40	00	03	00	00	00	40
0.0041	0.41	00	03.1	00	00	00	41
0.0042	0.42	00	03.2	00	00	00	42
0.0043	0.43	00	03.3	00	00	00	43
0.0044	0.44	00	03.4	00	00	00	44
0.0045	0.45	00	03.5	00	00	00	45
0.0046	0.46	00	03.6	00	00	00	46
0.0047	0.47	00	03.7	00	00	00	47
0.0048	0.48	00	03.8	00	00	00	48
0.0049	0.49	00	03.9	00	00	00	49
0.0050	0.50	00	04	00	00	00	50
0.0051	0.51	00	04.1	00	00	00	51
0.0052	0.52	00	04.2	00	00	00	52
0.0053	0.53	00	04.3	00	00	00	53
0.0054	0.54	00	04.4	00	00	00	54
0.0055	0.55	00	04.5	00	00	00	55
0.0056	0.56	00	04.6	00	00	00	56
0.0057	0.57	00	04.7	00	00	00	57
0.0058	0.58	00	04.8	00	00	00	58
0.0059	0.59	00	04.9	00	00	00	59
0.0060	0.60	00	05	00	00	00	60
0.0061	0.61	00	05.1	00	00	00	61
0.0062	0.62	00	05.2	00	00	00	62
0.0063	0.63	00	05.3	00	00	00	63
0.0064	0.64	00	05.4	00	00	00	64
0.0065	0.65	00	05.5	00	00	00	65
0.0066	0.66	00	05.6	00	00	00	66
0.0067	0.67	00	05.7	00	00	00	67
0.0068	0.68	00	05.8	00	00	00	68
0.0069	0.69	00	05.9	00	00	00	69
0.0070	0.70	00	06	00	00	00	70
0.0071	0.71	00	06.1	00	00	00	71
0.0072	0.72	00	06.2	00	00	00	72
0.0073	0.73	00	06.3	00	00	00	73
0.0074	0.74	00	06.4	00	00	00	74
0.0075	0.75	00	06.5	00	00	00	75
0.0076	0.76	00	06.6	00	00	00	76
0.0077	0.77	00	06.7	00	00	00	77
0.0078	0.78	00	06.8	00	00	00	78
0.0079	0.79	00	06.9	00	00	00	79
0.0080	0.80	00	07	00	00	00	80
0.0081	0.81	00	07.1	00	00	00	81
0.0082	0.82	00	07.2	00	00	00	82
0.0083	0.83	00	07.3	00	00	00	83
0.0084	0.84	00	07.4	00	00	00	84
0.0085	0.85	00	07.5	00	00	00	85
0.0086	0.86	00	07.6	00	00	00	86
0.0087	0.87	00	07.7	00	00	00	87
0.0088	0.88	00	07.8	00	00	00	88
0.0089	0.89	00	07.9	00	00	00	89
0.0090	0.90	00	08	00	00	00	90
0.0091	0.91	00	08.1	00	00	00	91
0.0092	0.92	00	08.2	00	00	00	92
0.0093	0.93	00	08.3	00	00	00	93
0.0094	0.94	00	08.4	00	00	00	94
0.0095	0.95	00	08.5	00	00	00	95
0.0096	0.96	00	08.6	00	00	00	96
0.0097	0.97	00	08.7	00	00	00	97
0.0098	0.98	00	08.8	00	00	00	98
0.0099	0.99	00	08.9	00	00	00	99
0.0100	1.00	01	00	00	00	00	100

Table A.1

Conversion Table for the Standard Normal Distribution

Oper. No.	Handle					KY	KY ²
	1	2	3	4	5		
1	80	73	141	81	142	517	58335
2	63	68	92	59	83	365	30547
3	53	39	55	41	53	241	11845
4	73	68	76	56	71	344	23906
5	120	114	92	74	93	493	49985
6	73	37	47	90	78	325	23091
7	72	101	98	87	129	487	49199
8	49	55	67	37	44	252	13220
9	74	71	63	90	169	467	51147
10	29	35	30	20	19	133	3727
11	107	100	55	102	128	492	51262
12	45	18	37	34	54	138	7790
13	27	12	12	0	73	126	6642
14	66	62	62	58	58	306	18772
15	57	70	73	87	75	362	26672
KX	938	943	1000	916	1271	5118	
KX ²	73946	72287	80492	68366	131049		426140

Table 7.
Computation data for 60° rotation.

A250000							A250000
1	2	3	4	5	6	7	
000000	000	000	000	000	000	000	0
000001	000	000	000	000	000	000	1
000002	000	000	000	000	000	000	2
000003	000	000	000	000	000	000	3
000004	000	000	000	000	000	000	4
000005	000	000	000	000	000	000	5
000006	000	000	000	000	000	000	6
000007	000	000	000	000	000	000	7
000008	000	000	000	000	000	000	8
000009	000	000	000	000	000	000	9
000010	000	000	000	000	000	000	10
000011	000	000	000	000	000	000	11
000012	000	000	000	000	000	000	12
000013	000	000	000	000	000	000	13
000014	000	000	000	000	000	000	14
000015	000	000	000	000	000	000	15
000016	000	000	000	000	000	000	16
000017	000	000	000	000	000	000	17
000018	000	000	000	000	000	000	18
000019	000	000	000	000	000	000	19
000020	000	000	000	000	000	000	20
000021	000	000	000	000	000	000	21
000022	000	000	000	000	000	000	22
000023	000	000	000	000	000	000	23
000024	000	000	000	000	000	000	24
000025	000	000	000	000	000	000	25
000026	000	000	000	000	000	000	26
000027	000	000	000	000	000	000	27
000028	000	000	000	000	000	000	28
000029	000	000	000	000	000	000	29
000030	000	000	000	000	000	000	30
000031	000	000	000	000	000	000	31
000032	000	000	000	000	000	000	32
000033	000	000	000	000	000	000	33
000034	000	000	000	000	000	000	34
000035	000	000	000	000	000	000	35
000036	000	000	000	000	000	000	36
000037	000	000	000	000	000	000	37
000038	000	000	000	000	000	000	38
000039	000	000	000	000	000	000	39
000040	000	000	000	000	000	000	40
000041	000	000	000	000	000	000	41
000042	000	000	000	000	000	000	42
000043	000	000	000	000	000	000	43
000044	000	000	000	000	000	000	44
000045	000	000	000	000	000	000	45
000046	000	000	000	000	000	000	46
000047	000	000	000	000	000	000	47
000048	000	000	000	000	000	000	48
000049	000	000	000	000	000	000	49

Oper. No.	Handle					XY	XY ²
	1	2	3	4	5		
1	70	34	158	64	115	499	55393
2	43	95	114	71	94	417	37747
3	45	30	60	20	95	250	15950
4	58	84	147	49	75	413	40053
5	99	90	137	56	97	479	49215
6	51	11	77	41	65	245	14557
7	99	91	95	100	161	546	63028
8	56	36	85	41	62	280	17182
9	104	38	64	70	63	339	25225
10	12	4	19	35	29	99	2587
11	108	88	106	134	143	579	69049
12	47	17	63	48	76	251	14547
13	35	0	18	19	44	116	3846
14	64	16	54	51	54	239	12785
15	131	79	60	112	95	497	51371
ΣX	1022	773	1275	911	1268	5249	
ΣX ²	84792	59605	132791	70327	125022		472537

Table 8.

Computation data for 90° rotation.

No.	Date	Miles					Total Miles
		1	2	3	4	5	
10000	1900	100	100	100	100	100	500
10001	1901	100	100	100	100	100	500
10002	1902	100	100	100	100	100	500
10003	1903	100	100	100	100	100	500
10004	1904	100	100	100	100	100	500
10005	1905	100	100	100	100	100	500
10006	1906	100	100	100	100	100	500
10007	1907	100	100	100	100	100	500
10008	1908	100	100	100	100	100	500
10009	1909	100	100	100	100	100	500
10010	1910	100	100	100	100	100	500
10011	1911	100	100	100	100	100	500
10012	1912	100	100	100	100	100	500
10013	1913	100	100	100	100	100	500
10014	1914	100	100	100	100	100	500
10015	1915	100	100	100	100	100	500
10016	1916	100	100	100	100	100	500
10017	1917	100	100	100	100	100	500
10018	1918	100	100	100	100	100	500
10019	1919	100	100	100	100	100	500
10020	1920	100	100	100	100	100	500
10021	1921	100	100	100	100	100	500
10022	1922	100	100	100	100	100	500
10023	1923	100	100	100	100	100	500
10024	1924	100	100	100	100	100	500
10025	1925	100	100	100	100	100	500
10026	1926	100	100	100	100	100	500
10027	1927	100	100	100	100	100	500
10028	1928	100	100	100	100	100	500
10029	1929	100	100	100	100	100	500
10030	1930	100	100	100	100	100	500

Table 1.

Comparison of the two methods.

Oper. No.	Handle						EY ²
	1	2	3	4	5	EY	
1	117	75	161	118	189	660	94880
2	60	86	97	81	71	395	32007
3	102	102	97	58	67	426	38070
4	103	92	164	142	146	647	87449
5	100	82	100	98	147	527	57937
6	79	16	105	58	76	334	26662
7	129	82	117	149	188	665	94599
8	38	108	165	86	102	499	58133
9	154	97	127	109	94	581	69971
10	55	21	74	46	64	260	15154
11	133	109	142	116	140	640	82790
12	70	62	81	65	93	371	28179
13	8	0	14	10	0	32	360
14	69	73	83	70	97	392	31288
15	153	79	95	111	117	555	64685
EX	1370	1084	1622	1317	1591	6984	
EX ²	150192	94402	198014	135577	203979		782164

Table 9.

Computation data for 120° rotation.

Computation Area for the Solution
Table 2.

Order	1	2	3	4	5	6	7
1	157	75	161	115	184	040	04000
2	05	05	77	77	77	77	77000
3	101	101	77	77	77	77	77000
4	101	05	101	101	101	101	04070
5	101	05	100	05	101	101	04070
6	77	10	101	05	77	05	04070
7	101	05	117	101	101	101	04070
8	05	101	101	05	101	101	04070
9	101	77	117	101	101	101	04070
10	05	05	77	05	77	101	10100
11	101	101	101	101	101	101	10100
12	77	05	05	05	05	101	10100
13	05	05	14	10	05	10	100
14	05	05	05	77	77	101	10100
15	101	77	77	111	111	111	10100
16	101	101	101	101	101	101	10100
17	101	101	101	101	101	101	10100

<u>30° rotation</u>		<u>60° rotation</u>	
T^2	245779.000	T^2	426140.000
Z^2	14371661.000	Z^2	26193924.000
$\frac{Z^2}{K^2}$	191622.413	$\frac{Z^2}{K^2}$	349252.320
$E(EK)^2$	2943017.000	$E(EK)^2$	5319890.000
$E(EY)^2$	1143949.000	$E(EY)^2$	1995020.000
Q	54156.567	Q	76887.680
Q_C	4878.720	Q_C	6407.010
Q_T	37567.367	Q_T	49751.630
Q_{θ}	12010.430	Q_{θ}	21728.990
Q_{θ}^2	214.473	Q_{θ}^2	368.017
Q_{θ}^2	1144.680	Q_{θ}^2	1351.752
Q_{θ}^2	2683.384	Q_{θ}^2	3553.691
F_C	5.337	F_C	3.484
F_T	12.511	F_T	9.153
F_C		F_T	
$F_{.05}$	2.530	$F_{.05}$	1.878
$F_{.01}$	3.674	$F_{.01}$	2.424
	$DF_1 = 4$		$DF_1 = 14$
	$DF_2 = 56$		$DF_2 = 56$

Table 10.

Computed values for individual angles of rotation.

<u>90° rotation</u>		<u>120° rotation</u>	
T^2	472537.000	T^2	732164.000
Z^2	27552001.000	Z^2	48776256.000
$\frac{Z^2}{\text{km}}$	367360.010	$\frac{Z^2}{\text{km}}$	650350.060
$E(XX)^2$	5705383.000	$E(XX)^2$	9948610.000
$E(YY)^2$	2162431.000	$E(YY)^2$	3667336.000
Q	105176.990	Q	131613.920
Q_0	12996.860	Q_0	12890.580
Q_T	63138.190	Q_T	67117.120
Q_0^2	27039.940	Q_0^2	31806.220
Q_0^2	492.856	Q_0^2	567.963
Q_0^2	3249.713	Q_0^2	3222.645
Q_R^2	4652.726	Q_R^2	6222.651
F_0	6.730	F_0	5.674
F_R	9.636	F_R	10.936
F_0		F_R	
$F_{.05}$	2.536 $D.F._1 = 4$	$F_{.05}$	1.878 $D.F._1 = 14$
$F_{.01}$	3.674 $D.F._2 = 56$	$F_{.01}$	2.424 $D.F._2 = 56$

Table 10.
(Continued)

Year	Value	Year	Value
1900	100,000	1900	100,000
1901	105,000	1901	105,000
1902	110,000	1902	110,000
1903	115,000	1903	115,000
1904	120,000	1904	120,000
1905	125,000	1905	125,000
1906	130,000	1906	130,000
1907	135,000	1907	135,000
1908	140,000	1908	140,000
1909	145,000	1909	145,000
1910	150,000	1910	150,000
1911	155,000	1911	155,000
1912	160,000	1912	160,000
1913	165,000	1913	165,000
1914	170,000	1914	170,000
1915	175,000	1915	175,000
1916	180,000	1916	180,000
1917	185,000	1917	185,000
1918	190,000	1918	190,000
1919	195,000	1919	195,000
1920	200,000	1920	200,000

1900 100,000
 1901 105,000
 1902 110,000
 1903 115,000
 1904 120,000
 1905 125,000
 1906 130,000
 1907 135,000
 1908 140,000
 1909 145,000
 1910 150,000
 1911 155,000
 1912 160,000
 1913 165,000
 1914 170,000
 1915 175,000
 1916 180,000
 1917 185,000
 1918 190,000
 1919 195,000
 1920 200,000

Q(total)	436672.787		
Q(handles)	27219.887	σ_h^2	6804.972
Q(angles)	68637.613	σ_a^2	12879.204
Q(operators)	207382.187	σ_o^2	14311.585
Q(handles vs. angles)	8655.287	σ_{ha}^2	721.274
Q(handles vs. operators)	33235.213	σ_{ho}^2	593.486
Q(angles vs. operators)	32212.187	σ_{ao}^2	766.957
Q(residual)	59350.413	σ_e^2	353.276

F_h	19.262	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 2.43 \\ 3.44 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 4 \\ D.F_2 = 42 \end{array} \right\}$
F_a	64.763	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 2.67 \\ 3.91 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 3 \\ D.F_2 = 56 \end{array} \right\}$
F_{ha}	2.042	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 1.82 \\ 2.30 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 12 \\ D.F_2 = 14 \end{array} \right\}$
F_{ho}	1.680	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 1.42 \\ 1.60 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 56 \\ D.F_2 = 3 \end{array} \right\}$
F_o	41.928	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 1.76 \\ 2.20 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 14 \\ D.F_2 = 12 \end{array} \right\}$
F_{ao}	2.171	$\left\{ \begin{array}{l} F_{.05} \\ F_{.01} \end{array} \right.$	$\left\{ \begin{array}{l} 1.47 \\ 1.72 \end{array} \right.$	$\left. \begin{array}{l} D.F_1 = 42 \\ D.F_2 = 4 \end{array} \right\}$

Table 11.

Computed values for complete data.

100,000	100,000	100,000	100,000
200,000	200,000	200,000	200,000
300,000	300,000	300,000	300,000
400,000	400,000	400,000	400,000
500,000	500,000	500,000	500,000
600,000	600,000	600,000	600,000
700,000	700,000	700,000	700,000
800,000	800,000	800,000	800,000
900,000	900,000	900,000	900,000

100,000	100,000	100,000	100,000	100,000	100,000
200,000	200,000	200,000	200,000	200,000	200,000
300,000	300,000	300,000	300,000	300,000	300,000
400,000	400,000	400,000	400,000	400,000	400,000
500,000	500,000	500,000	500,000	500,000	500,000
600,000	600,000	600,000	600,000	600,000	600,000
700,000	700,000	700,000	700,000	700,000	700,000
800,000	800,000	800,000	800,000	800,000	800,000
900,000	900,000	900,000	900,000	900,000	900,000

Table 11

Source: Bureau of Economic Analysis

APPENDIX C.

SAMPLE DATA SHEETS

SAMPLE OPERATOR DATA SHEET

Operator No. _____ Weight _____
 Date _____ Height _____
 Date of Birth _____ Wear glasses? _____
 Color Blind? _____ Visual defects? _____
 Nature of visual defects _____

 Any broken bones or physical defects of arms or hands? _____
 What bones broken? _____
 What physical defects? _____
 How much experience at operating this type of switch? _____

 How do you feel? Unusually good _____ Good _____ Average _____
 Poor _____ Tired _____
 How did you spend the last hour?
 Class _____ Taking a test _____ Studying _____ Working _____ Eating _____
 Relaxing _____ Other _____

AFTER TAKING TEST

To what extent were you prompted to work rapidly?
 Greatly _____ Indifferently _____ Poorly _____
 Distance of chair from table _____
 Ambient illumination: Bright _____ Average _____ Dim _____

Figure 6.

THEORY OF THE EARTH

The first part of the theory is the study of the earth's structure and the forces which have shaped it. This is done by the study of the earth's rocks and the fossils which they contain. The second part of the theory is the study of the earth's climate and the changes which have taken place in it. This is done by the study of the earth's ice and the remains of ancient plants and animals.

The third part of the theory is the study of the earth's life and the changes which have taken place in it. This is done by the study of the earth's plants and animals and the fossils which they contain. The fourth part of the theory is the study of the earth's history and the changes which have taken place in it. This is done by the study of the earth's rocks and the fossils which they contain.

The fifth part of the theory is the study of the earth's future and the changes which are likely to take place in it. This is done by the study of the earth's rocks and the fossils which they contain. The sixth part of the theory is the study of the earth's present and the changes which are taking place in it. This is done by the study of the earth's rocks and the fossils which they contain.

The seventh part of the theory is the study of the earth's past and the changes which have taken place in it. This is done by the study of the earth's rocks and the fossils which they contain. The eighth part of the theory is the study of the earth's future and the changes which are likely to take place in it. This is done by the study of the earth's rocks and the fossils which they contain.

Oper. #1	
Hand.	Angle
	30° 60° 90° 120°
1	
2	
3	
4	
5	

Oper. #2	
Hand.	Angle
	30° 90° 60° 120°
2	
3	
4	
5	
1	

Oper. #3	
Hand.	Angle
	30° 90° 120° 60°
3	
4	
5	
1	
2	

Oper. #4	
Hand.	Angle
	120° 60° 30° 90°
4	
3	
2	
5	
1	

Oper. #5	
Hand.	Angle
	60° 120° 30° 90°
5	
2	
3	
1	
4	

Oper. #6	
Hand.	Angle
	60° 90° 120° 30°
4	
5	
1	
2	
3	

Figure 9.

Sample data sheet.

10. 1940

10. 1940

10. 1940				Total	10. 1940				Total
Jan	Feb	Mar	Apr		Jan	Feb	Mar	Apr	
				1					1
				2					2
				3					3
				4					4
				5					5
				6					6

10. 1940

10. 1940

10. 1940				Total	10. 1940				Total
Jan	Feb	Mar	Apr		Jan	Feb	Mar	Apr	
				7					7
				8					8
				9					9
				10					10
				11					11

10. 1940

10. 1940

10. 1940				Total	10. 1940				Total
Jan	Feb	Mar	Apr		Jan	Feb	Mar	Apr	
				12					12
				13					13
				14					14
				15					15
				16					16

10. 1940

10. 1940

Oper. #7				
Hand.	Angle			
	90°	60°	30°	120°
5				
1				
4				
3				
2				

Oper. #8				
Hand.	Angle			
	30°	120°	90°	60°
5				
4				
3				
2				
1				

Oper. #9				
Hand.	Angle			
	120°	30°	60°	90°
1				
4				
2				
3				
5				

Oper. #10				
Hand.	Angle			
	60°	30°	120°	90°
5				
1				
5				
4				
2				

Oper. #11				
Hand.	Angle			
	90°	120°	30°	60°
1				
5				
2				
3				
4				

Oper. #12				
Hand.	Angle			
	120°	90°	60°	30°
2				
1				
5				
4				
3				

Figure 9.
(Continued)

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

align

,bword

%ld, %ld, %ld, %ld

0

1

2

3

4

W1, v1000

(bword/4)

Oper. #13					Oper. #14				
Hand.	Angle				Hand.	Angle			
	90°	30°	120°	60°		60°	120°	90°	30°
3					2				
5					3				
1					4				
2					1				
4					3				

Oper. #15				
Hand.	Angle			
	90°	30°	60°	120°
4				
2				
1				
5				
3				

Figure 9.
(Continued)

215. 1960

edge

.2000

Pos	Pos	Pos	Pos	
				1
				4
				6
				1
				5

216. 1960

edge

.2000

Pos	Pos	Pos	Pos	
				8
				4
				1
				2
				1

217. 1960

edge

.2000

Pos	Pos	Pos	Pos	
				1
				1
				1
				1
				1

218. 1960

edge

.2000

Pos	Pos	Pos	Pos	
				5
				8
				1
				8
				6

219. 1960

edge

.2000

Pos	Pos	Pos	Pos	
				1
				1
				1
				1
				1

220. 1960

edge

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